Introducing non-invasive positive pressure ventilation

Preston R (2001) Introducing non-invasive positive pressure ventilation. *Nursing Standard*. 15, 26, 42-45. Date of acceptance: October 24 2000.

Roland Preston BA, Dip PS, RGN, is Lecturer Practitioner, Ayr Hospital/Paisley University, Ayrshire. Email: pres-nm0@wpmail.paisley.ac.uk

Summary

Non-invasive ventilation techniques provide and enhance alveolar ventilation without the need for an endotracheal airway. These techniques are increasingly being used by nurses to manage patients with type 2 respiratory failure. The author outlines the advantages of, and criteria and contraindications for, using bi-level positive airway pressure (BiPAP).

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Key words

- Nursing: procedures
- Respiratory disorders
- Ventilation: mechanical

These key words are based on subject headings from the British Nursing Index. This article has been subject to double-blind review.

OVER THE past ten years, non-invasive positive pressure ventilation (NIPPV) techniques have increasingly been used in the treatment of patients with chronic respiratory insufficiency to manage acute or chronic respiratory failure without intubation and conventional mechanical ventilation. In selected patient groups, this treatment option is rapidly becoming an accepted method of supporting ventilation without the hazards associated with endotracheal intubation (Juniper and Hardinge 1998). Bi-level positive airway pressure (BiPAP) ventilation was introduced to clinical practice on the respiratory medical ward at the Ayr Hospital three years ago. BiPAP non-invasive ventilation increases the treatment options for patients with type 2 respiratory failure, who were traditionally managed with drug therapy or referred to intensive care for conventional ventilation.

History of ventilation

Mechanical ventilation was being used in the treatment of respiratory failure as early as the 1840s (Marcet 1854), although it was not until the 1950s that non-invasive negative pressure techniques, such as the 'iron lung', were more extensively used. Further advancements in technology and the development of endotracheal tubes preceded invasive ventilation techniques, which became the standard method of supporting or assisting ventilation. There are, however, a number of complications associated with invasive ventilation techniques: decreased cardiac output, aspiration, tension pnuemothorax, bronchospasm, laryngeal trauma, sinusitis and pneumonia (Juniper and Hardinge 1998, Stauffer *et al* 1981). Factors such as the patient's age, quality of life and predicted ventilatory dependence should be taken into account before invasive ventilatory management is initiated. This type of therapy might be considered inappropriate for some patients, such as those suffering from end-stage respiratory failure who are oxygen dependent, even in the home setting. Until about six years ago this was the only option available to support patients with a life-threatening reversible deterioration in respiratory function. Nasal and full-face mask positive pressure ventilation (NPPV) techniques are rapidly becoming an accepted method of non-invasive ventilation and can reduce hazards associated with endotracheal intubation, as well as decreasing hospital costs by preventing patient admission to intensive care units (Kannan 1999).

Juniper and Hardinge (1998) acknowledge that NPPV is being used increasingly in high dependency areas and on general wards. At Ayr Hospital, full-face or nasal mask BiPAP ventilation, via the ventilator (Fig. 1), is used on the respiratory ward to treat acute respiratory failure due to exacerbation of chronic obstructive pulmonary disease (COPD). Over the past two years, the uses of this non-invasive ventilator have increased. It is now being successfully used in the intensive care and high dependency units to treat patients suffering from cardiogenic pulmonary oedema and pneumonia, and also for patients who are difficult to wean or who fail to wean from invasive mechanical ventilation.

NIPPV and BiPAP

Non-invasive ventilation refers to techniques that provide and enhance alveolar ventilation without the use of an endotracheal airway and can be accomplished using positive or negative pressure techniques (Jasmer *et al* 1997, Kannan 1999, Shudham 1998). NPPV gives the patient breathing assistance by delivering a pressurised gas flow through a tight-fitting mask. NPPV aids breathing by:

- Decreasing the work of breathing.
- Increasing the volume of inhaled air in each breath (tidal volume).
- Increasing blood oxygen levels.

BiPAP This is the newest form of non-invasive ventilation. In normal respiration, each breath consists of two phases: an inspiratory and an expiratory phase. BiPAP works by providing assistance during the inspiratory phase of respiration and preventing airway closure during the expiratory phase. Assistance during the inspiratory phase is in the form of pressure support. As the patient breathes in, the equipment generates a positive pressure (pressure higher than the atmospheric pressure) at a level pre-set by the clinician. This positive pressure support is termed 'inspiratory positive airway pressure' (IPAP). IPAP increases the patient's tidal volume, thus increasing minute ventilation (tidal volume x respiratory rate per minute) and ultimately alveolar ventilation. An increase in minute and alveolar ventilation decreases carbon dioxide levels in the arterial blood ($PaCO_2$) and alleviating dyspnoea, thus reducing the use of accessory muscles.

Pressure support ends at the start of the expiratory phase of respiration, but a continuous positive pressure, known as positive end expiratory pressure (PEEP) or continuous positive airway pressure (CPAP), is maintained within the airways. PEEP and CPAP apply positive pressure at the end of each expiration, which helps to inflate the alveoli and keep them open. This increases the surface area for gaseous exchange. On the BiPAP machine, PEEP/CPAP is termed 'expiratory positive airway pressure' (EPAP). EPAP increases the functional residual capacity of the lungs (the volume of air that remains in the lungs at the end of normal expiration) and decreases or prevents airway closure. Areas of collapsed lung tissue resulting from atelectasis can be re-expanded and fluid accumulation due to pulmonary oedema can be prevented or reduced. Increasing the functional residual capacity of the lung can result in an increase in arterial oxygen (PaO_2) levels, however, supplemental oxygen can be administered if required.

The BiPAP ventilator alternates between IPAP and EPAP levels at respiratory frequencies that synchronise with the patient's breathing pattern. As the patient inspires, the ventilator delivers IPAP, which stops as the patient expires, but pressure within the airways remains positive because of the EPAP.

Different modes of non-invasive ventilation Three different modes of non-invasive ventilation are available on the BiPAP ventilator: spontaneous, spontaneous/timed and timed. In spontaneous mode, the patient triggers all inspirations; in spontaneous/timed mode the number of breaths per minute (BPM) is pre-set and these are synchronised with the patient's breathing activity. If the patient does not initiate a breath, the ventilator will trigger the inspiratory phase, giving the patient a ventilator-assisted breath.

Fig. 1. BiPAP non-invasive ventilator

Fig. 2. Control settings on BiPAP ventilator

Spontaneous mode is used in patients who have an adequate respiratory rate, while spontaneous/timed mode is used when the patient is not maintaining an adequate respiratory rate and a back-up rate is desirable. Timed mode can be useful in patients who have problems synchronising their breathing with BiPAP, such as patients with tachypnoea. In timed mode, the percentage of the respiratory cycle for inspiration can be manipulated, thus allowing variable times for inspiration depending on the patient's condition. Figure 2 shows the control settings on a BiPAP ventilator.

Criteria for commencing BiPAP In an acute exacerbation of COPD, the work of breathing is increased, which results in reduced alveolar ventilation, causing carbon dioxide (CO_2) retention, a reduction in oxygen (O_2) levels and respiratory acidosis (Stauffer *et al* 1981). BiPAP ventilation results in:

Box 1. Contraindications for BiPAP

- Lobar pneumonia
- Acute exacerbation of asthma
- Patients unable to tolerate mask
- Patients susceptible to gastric distention requiring nasogastric tube placement
- Patients with bullous disease or any disease that predisposes them to pneumothorax
- Haemodynamic instability
- Allergy to face mask material
- Patients who need to remove mask frequently for expectoration

Fig. 3. Mask sizing chart

Fig. 4. Full-face mask with restraining straps

David Mitchell

- A decrease in respiratory muscle effort due to assisted inspiration.
- Increased tidal volumes as a result of a reduction in inspiratory effort.
- Reduced respiratory rate as the efficiency of breathing is increased.
- Reduced CO_2 levels as alveolar ventilation is improved.
- Increased O_2 levels due to increased functional residual capacity.

It is important that the following criteria are met before starting patients on BiPAP:

- The patient must be conscious and breathing spontaneously.
- He or she must have an adequate gag and cough reflex.
- The patient must be cognitively aware so that he or she knows if and when the mask needs to be removed, for example, if the patient vomits.

Correct placement, position and size of the full-face or nasal mask (Fig. 3) is a key factor in the success of BiPAP ventilation. The full-face mask is used in Ayr Hospital. From personal experience these masks are better than nasal for patients who are dyspnoeic or tachypnoeic as they tend to mouthbreathe, thus reducing the effectiveness of non-invasive ventilation. The mask is held in position using restraining straps, ensuring a tight seal to maintain expiratory positive airway pressure (Fig. 4). If the mask is fitted too tightly, pressure necrosis can develop, especially over the bridge of the nose, and the patient might be uncomfortable and might not tolerate the therapy. Masks that are too loose cause air leaks, which reduce the efficiency of the system and EPAP. It is imperative that the mask has a quick release system (Fig. 4) that can be operated by the patient should he or she need to remove it. Contra-indications for the use of BiPAP ventilation are listed in Box 1.

Advantages of BiPAP As with other modes of non-invasive ventilation, BiPAP has a number of advantages:

- The ability to preserve normal swallowing, speech, feeding and coughing mechanisms.
- Normal humidification of inspired gases is maintained because the upper airway is not bypassed.
- The absence of an endotracheal airway means that the patient does not require sedation.

Initiating BiPAP therapy

Patients at Ayr Hospital are assessed for BiPAP by the nursing staff. They must meet the criteria outlined in the protocol before BiPAP is initiated (Box 2). Patients who are unable to protect the airway or clear secretions, and those with a pneumothorax, lobar pneumonia, acute severe asthma or a systolic blood pressure below 85mmHg are excluded from BiPAP.

Haemodynamic instability, such as uncontrolled cardiac dysrhythmias or low systolic blood pressure below 85mmHg and severe hypoxaemia with a PaO_2 below 60mmHg (8kPa) on 100 per cent oxygen can contraindicate the use of BiPAP (Kannan 1999). Arterial blood gases should always be checked and the patient assessed to ensure that he or she meets the entry criteria before commencing BiPAP. If the patient is suitable for BiPAP, the procedure should be explained fully and he or she measured for correct mask size. Familiarising the patient with the equipment is an important aspect of initiating therapy, as this information might help to relieve patient anxiety about starting ventilation. The patient should be shown the mask and instructed in the use of the quick release strap. The importance of keeping the mask on should be explained and the patient informed about the noise the machine generates. The initial BiPAP settings are:

- IPAP – set at 8cmH_2O.
- EPAP – set at 4cmH_2O.
- Oxygen can be connected directly to the face mask using oxygen tubing and is delivered at an initial flow rate of one litre per minute.

Adjusting BiPAP Arterial blood gases are repeated one hour, four hours and eight hours after commencing BiPAP, or more often if clinically indicated. Monitoring pulse oximetry alone is insufficient in assessing the full effects of BIPAP as it gives no indication of $PaCO_2$ levels. IPAP is gradually increased over 30-60 minutes to the maximum level the patient will comfortably tolerate: this is usually 12-20cmH_2O. The percentage of oxygen can be adjusted on consultation with medical staff to maintain oxygen saturation above 90 per cent.

Nursing care

Patients require a high level of psychological preparation and support during the initial stages of BiPAP ventilation. Breathless patients are often anxious and agitated as a result of hypoxia, and might require constant monitoring and assessment until ventilation therapy has been established. Once the patient is adequately ventilated, agitation usually lessens. Psychological support should include an explanation of the equipment used, including the ventilator. The patient and his or her family should be given reassurance regarding safety aspects and the need for BiPAP.

Accurate mask fitting is vital to the success of this therapy and time must be spent familiarising the patient with the mask and how to remove it using the quick release strap. Careful explanation about the need for wearing the mask continuously is also necessary. The most comfortable mask interface should be used as this will help to ensure patient compliance with therapy. The ventilator compensates for small air leaks from the masks and these are permissible provided they are not near the patient's eyes as this can lead to drying and conjunctivitis (Kannan 1999). Compensation for small air leaks means that maintaining an airtight mask is unnecessary, which can improve patient compliance. As a tight-fitting mask can cause pressure necrosis at the bridge of the nose, frequent inspection of this site should be carried out. Various pressure-relieving cushions for the mask are available to reduce or eliminate this problem and promote comfort.

Patients on BiPAP require close observation and monitoring of vital signs until their condition stabilises. Continuous monitoring of oxygen saturation is vital. Continuous ECG monitoring and recording of the patient's blood pressure at 15-minute intervals is advocated during the acute period. Cardiac monitoring can be discontinued and the frequency of blood pressure measurement reduced once the patient's condition has stabilised. Observation of respiratory rate and use of accessory muscles gives an indication of how the patient is responding to ventilation therapy. A reduction in respiratory rate and accessory muscle use is expected as the patient's condition improves. Gastric distension is a possible complication of BiPAP non-invasive ventilation and frequent assessment of the abdomen should be carried out. If gastric distension is present, a nasogastric tube should be passed to release the air.

As the patient's condition stabilises, BiPAP can be stopped intermittently for short periods of up to 15 minutes to allow oral intake. The mask can also be removed for expectoration.

Conclusion

The introduction of BiPAP non-invasive ventilation for patients on a general ward requires ward nurses to learn about new equipment and develop new skills in caring for this group of patients. The lecturer practitioner and ward sister at Ayr hospital developed a training programme in the use of BiPAP equipment and mask fitting for all ward, intensive care and high dependency unit staff. Nursing staff also attended lectures on blood gas analysis and interpretation, as well as the mechanisms of BiPAP ventilation. Support for ward nurses is provided by senior nurses, the ward sister and lecturer-practitioner.

The introduction of BiPAP ventilation on the respiratory ward has provided another treatment option for those patients who meet the inclusion criteria. This initiative appears to have resulted in a reduction in the number of patients referred to intensive care for conventional ventilation methods, although these figures have not been audited. BiPAP ventilation has also been used to successfully treat patients on the intensive care unit who are not suitable for invasive ventilation. An informal audit of intensive care patients has demonstrated a success rate of over 75 per cent and a more detailed long-term audit is planned in the near future.

This method of respiratory support is a nurse-led therapy. Increased knowledge has empowered the nursing staff to be more proactive in the treatment and management of respiratory patients. To ensure that patients are cared for by suitably qualified staff, BiPAP ventilation is only carried out on the respiratory ward and high dependency and intensive care units.

BiPAP is a safe and effective means of supporting ventilation in acute respiratory failure. The main benefit for many patients is that it decreases the need for endotracheal intubation and invasive ventilation. Another advantage of using BiPAP over other more invasive forms of ventilation is that patients remain in control of their treatment and can communicate, eat and drink while experiencing improvement in respiratory symptoms

Contributors

Frances Kelly RGN, DipPS, Ward Sister, and Morag McNulty RGN, Senior Staff Nurse, Ayr Hospital, Ayrshire.

Box 2. Entry criteria for BiPAP ventilation

Respiratory failure:
- Acute exacerbation of chronic obstructive airways disease (COPD)
- Bronchiectasis
- Chest wall deformity, for example kyphoscoliosis

Arterial blood gases:
- PaO_2 (on air) < 50mmHg (7kPa) or PaO_2 (on oxygen) < 70mmHg (10kPa)
- $PaCO_2$ > 45mmHg (6.5kPa)
- pH < 7.35

Baseline measurements for the following should be recorded before commencing BiPAP:
- Heart rate
- Blood pressure
- Respiratory rate
- Use of accessory muscles
- Breath sounds
- Arterial blood gases
- Oxygen saturation (SpO_2)
- Chest X-ray

REFERENCES

Jasmer RM *et al* (1997) Non-invasive positive pressure ventilation for acute respiratory failure: underutilized or overrated. *Chest*. 111, 6, 1672-1678.

Juniper MC, Hardinge FM (1998) Non-invasive ventilation: a technique with increasing applications. *Care of the Critically Ill*. 14, 6, 201-205.

Kannan S (1999) Practical issues in non-invasive positive pressure ventilation. *Care of the Critically Ill*. 15, 3, 76-79.

Marcet W (1854) An account of a new instrument for performing artificial respiration. *Medical Times Gazette*. 8, 401.

Shudham C (Ed) (1998) *Neuromuscular Lung Disorders in Cardiorespiratory Nursing*. Cheltenham, Stanley Thornes.

Stauffer JL *et al* (1981) Complications and consequences of endotracheal intubation and tracheotomy: a prospective study of 150 critically ill adult patients. *American Journal of Medicine*. 70, 1, 65-76.